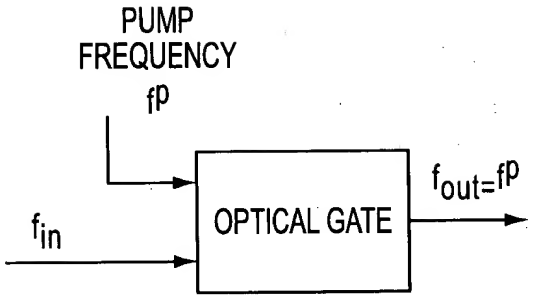

PUMP
FREQUENCY
f^p
f_{in}
OPTICAL GATE
$f_{out}=f^p$

FIG. 1

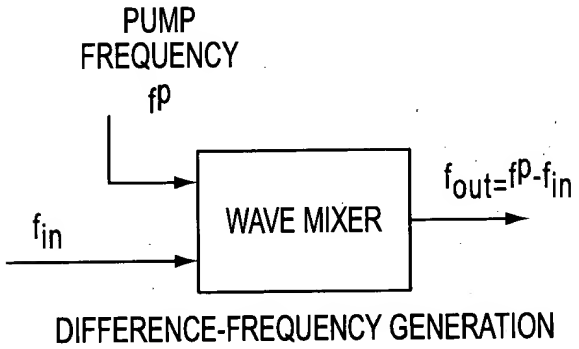

PUMP
FREQUENCY
f^p
f_{in}
WAVE MIXER
$f_{out}=f^p-f_{in}$
DIFFERENCE-FREQUENCY GENERATION

FIG. 2

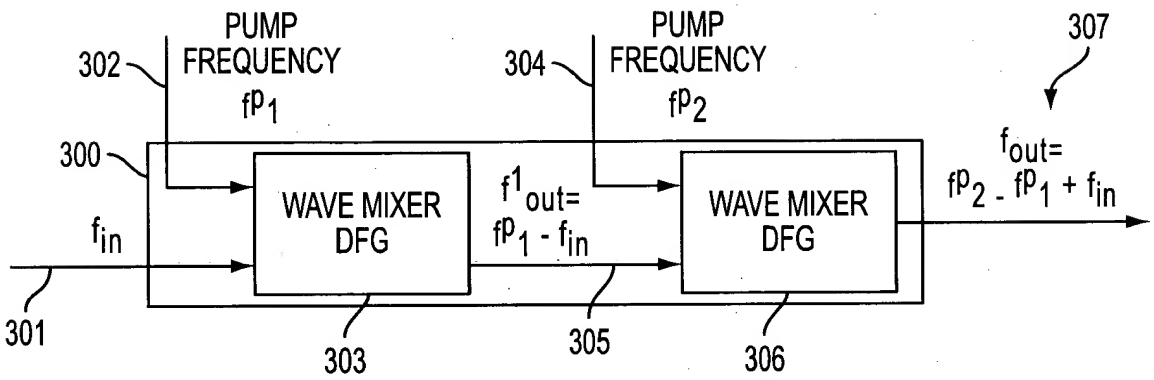

PUMP
FREQUENCY
f^{P}_{1}
302
PUMP
FREQUENCY
f^{P}_{2}
304
307
300
WAVE MIXER
DFG
WAVE MIXER
DFG
$f^{1}_{out}=$
$f^{P}_{1} - f_{in}$
$f_{out}=$
$f^{P}_{2} - f^{P}_{1} + f_{in}$
f_{in}
301
303
305
306

FIG. 3

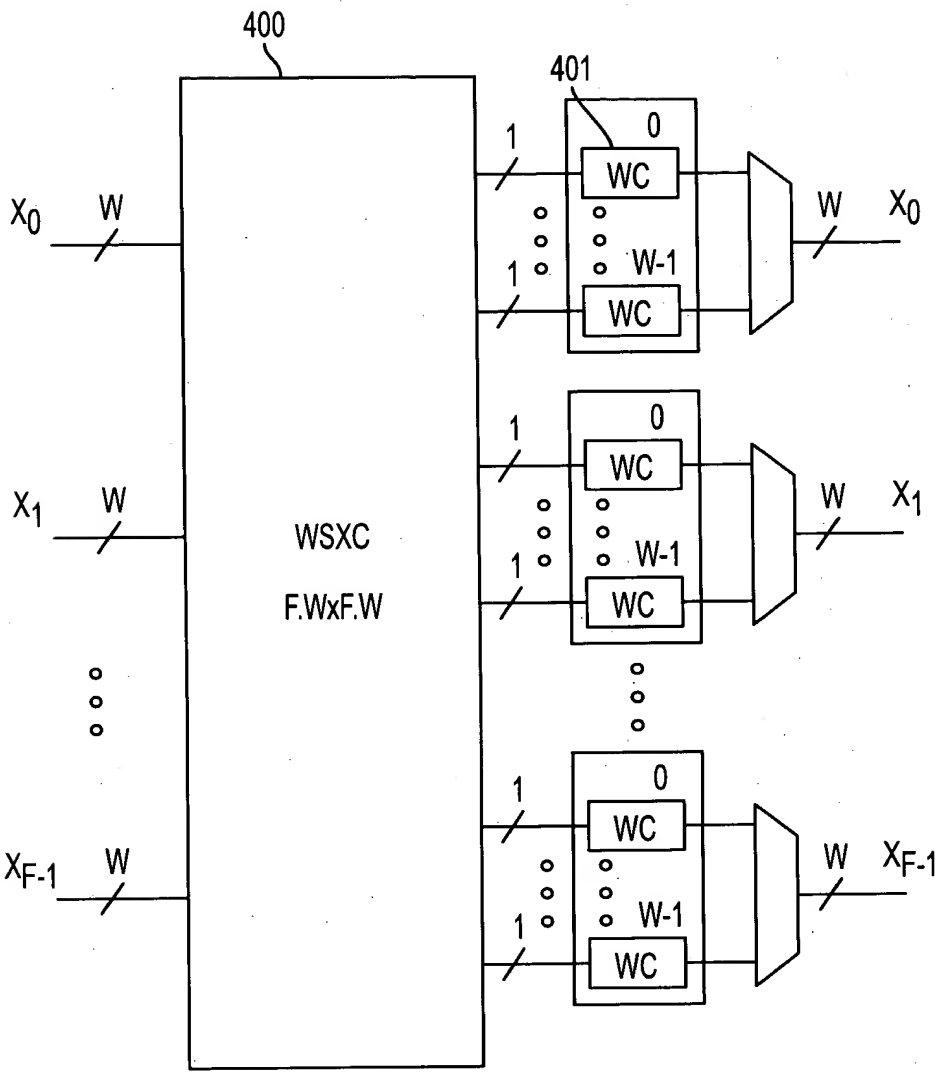


FIG. 4

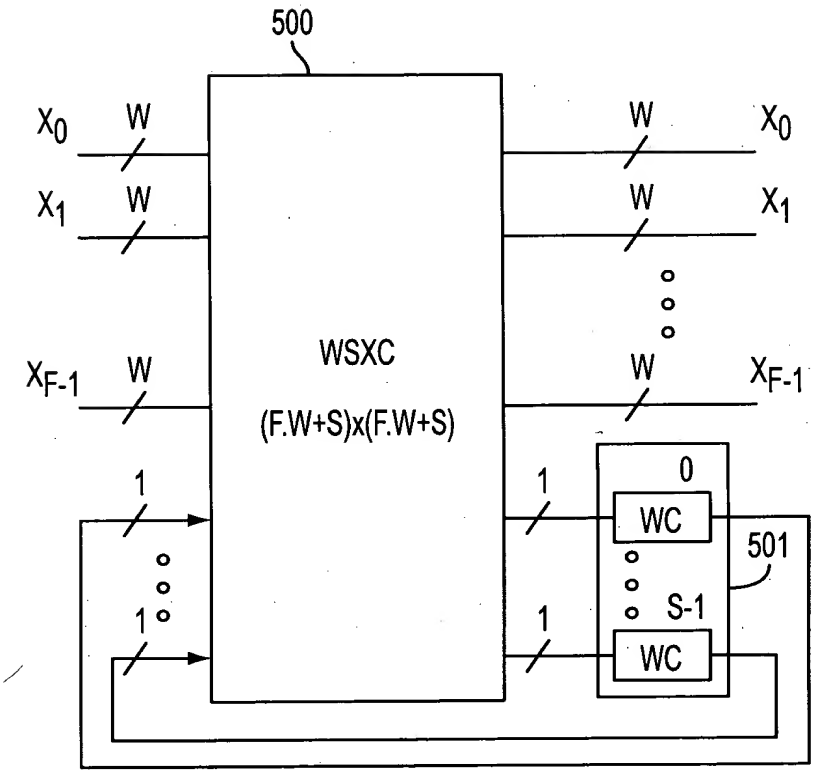


FIG. 5

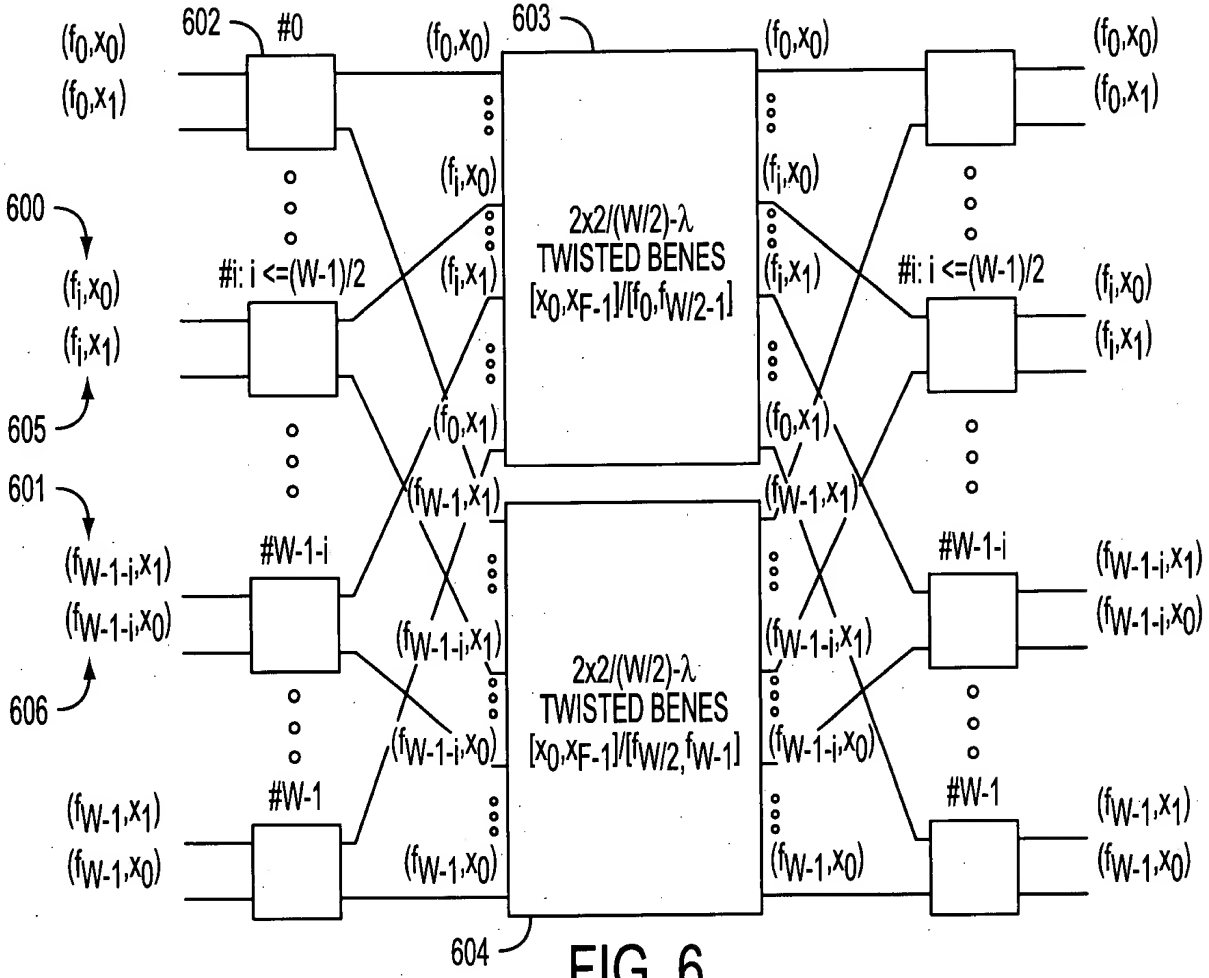
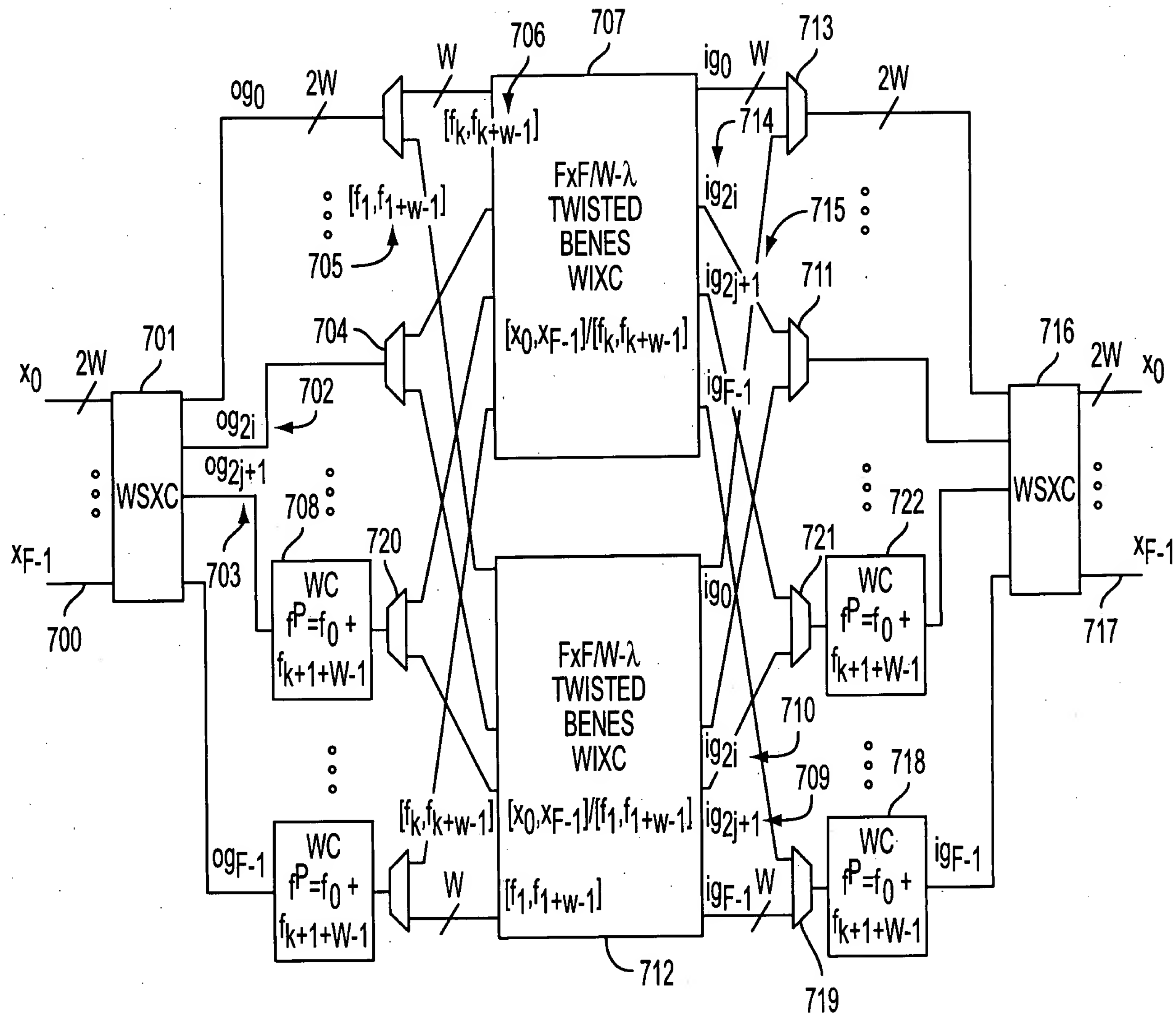

602
#0
603
600
#i: i <=(W-1)/2
605
601
#W-1-i
606
#W-1
2x2/(W/2)-λ
TWISTED BENES
[x0,xF-1]/[f0,fW/2-1]
2x2/(W/2)-λ
TWISTED BENES
[x0,xF-1]/[fW/2,fW-1]
604

FIG. 6



WSXC
WSXC
FxF/W-λ TWISTED BENES WIXC
$[x_0,x_{F-1}]/[f_k,f_{k+w-1}]$
FxF/W-λ TWISTED BENES WIXC
$[x_0,x_{F-1}]/[f_1,f_{1+w-1}]$
$[f_1,f_{1+w-1}]$
$[f_k,f_{k+w-1}]$
WC
$f^P=f_0+f_{k+1+W-1}$
x_0
x_{F-1}
2W
W
og_0
og_{2i}
og_{2j+1}
og_{F-1}
ig_0
ig_{2i}
ig_{2j+1}
ig_{F-1}
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722

FIG. 7

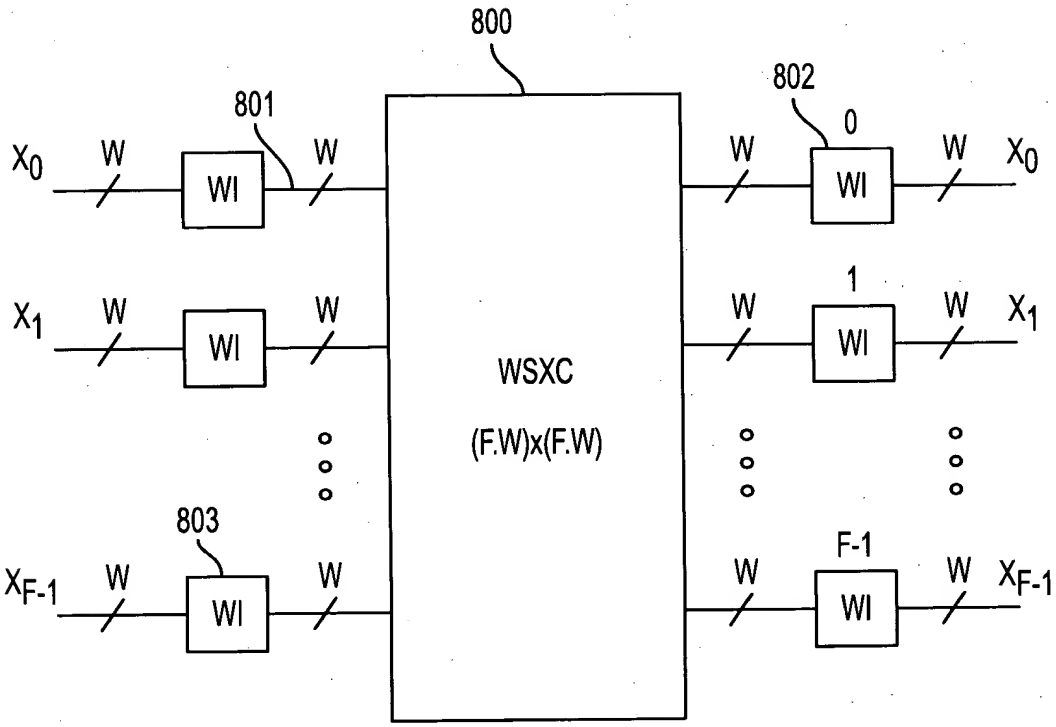


FIG. 8

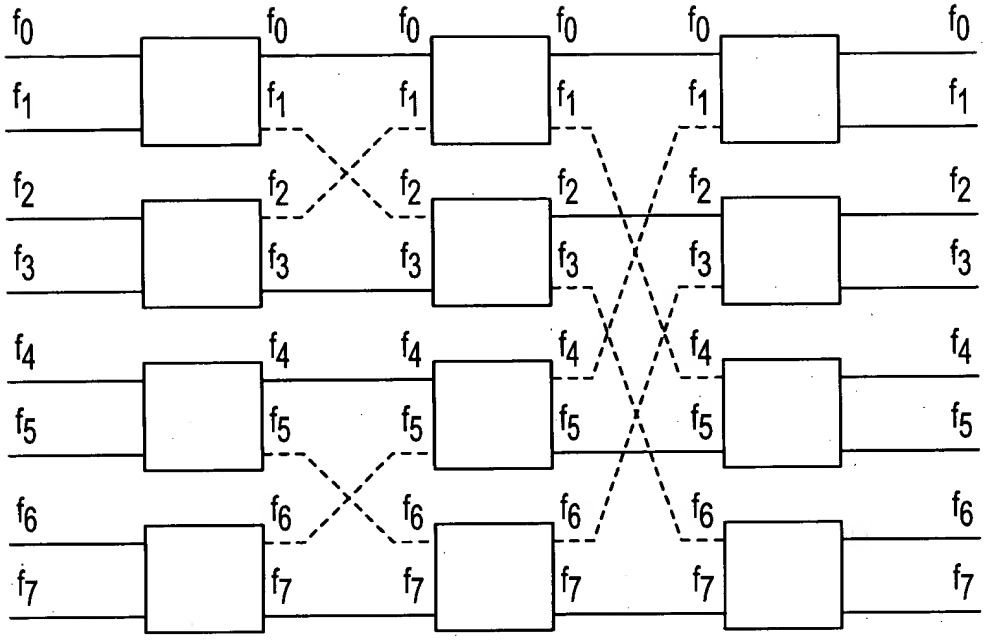
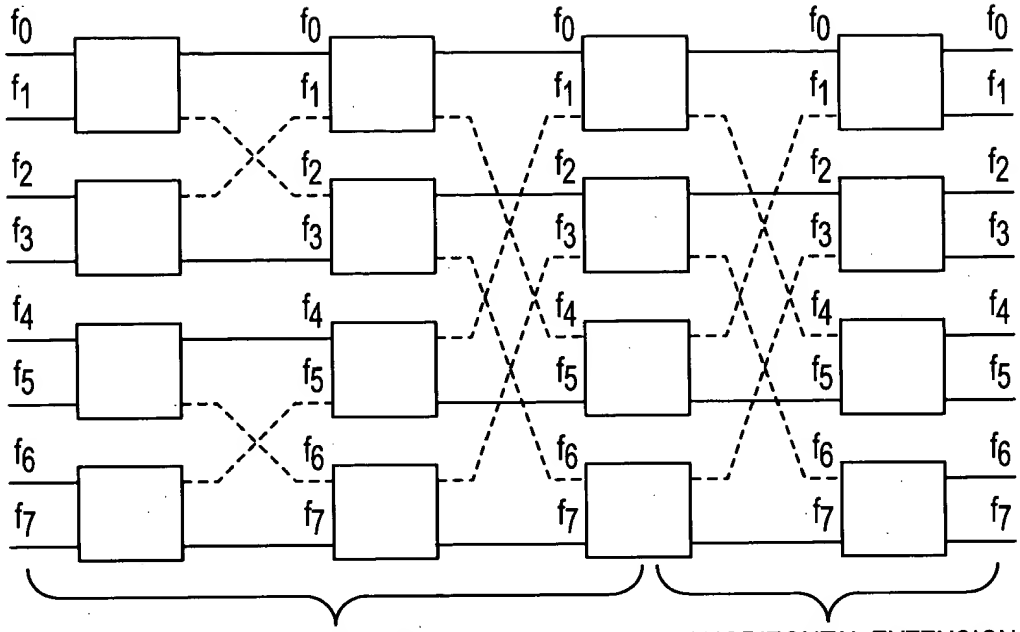


FIG. 9

$LOG_2(8,1,1)$NETWORK



$LOG_2(8,2,1)$NETWORK

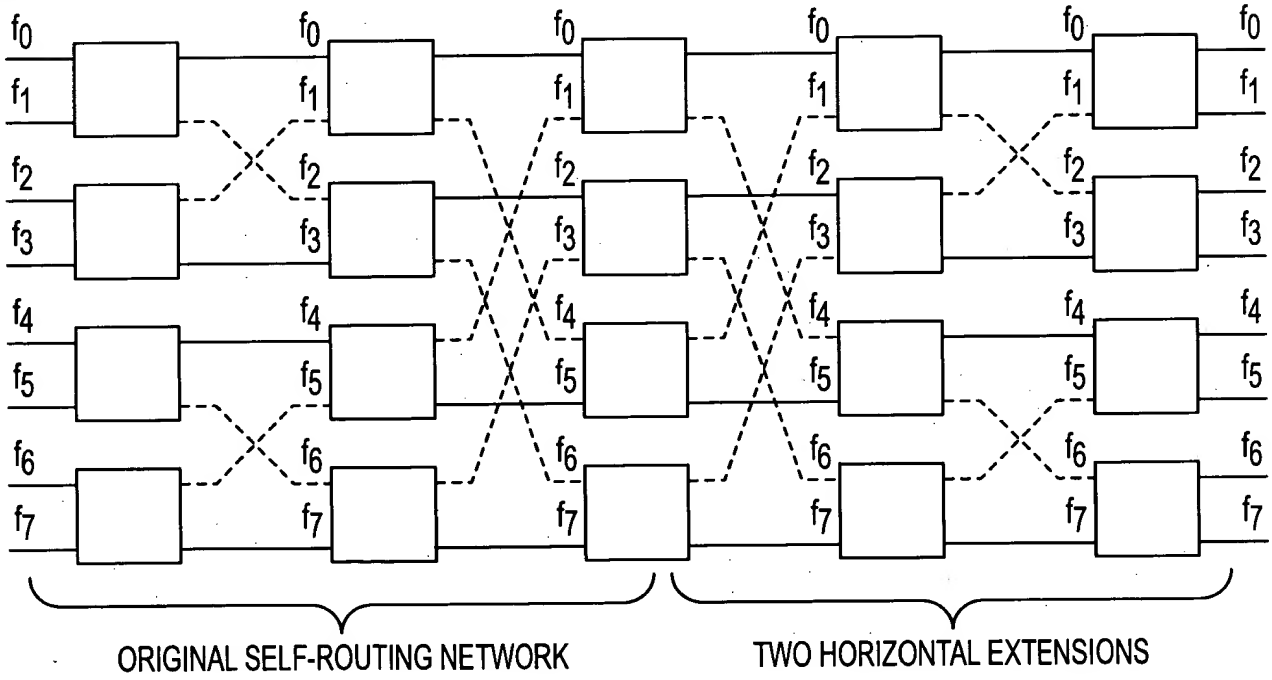


FIG. 10

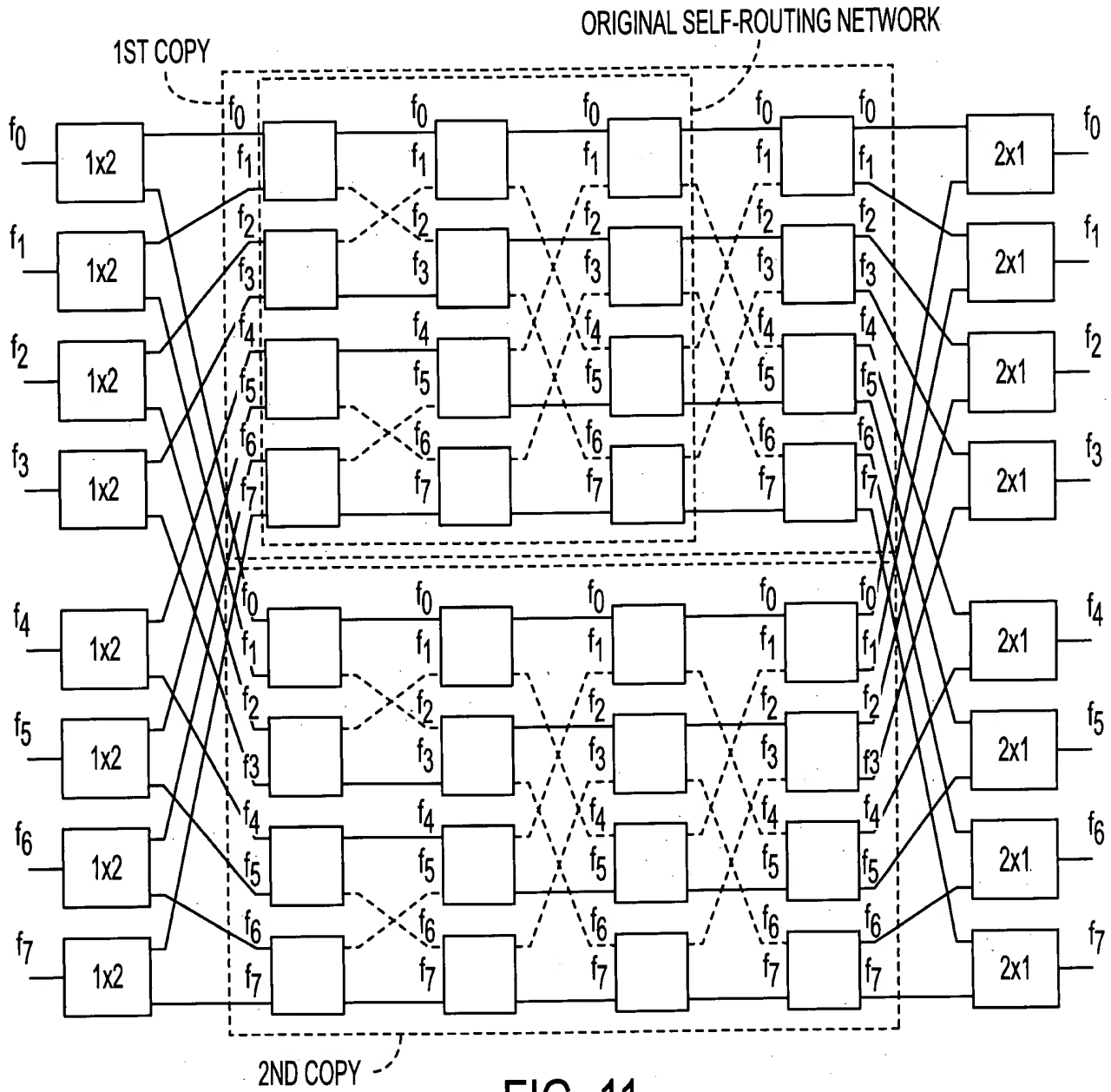


FIG. 11

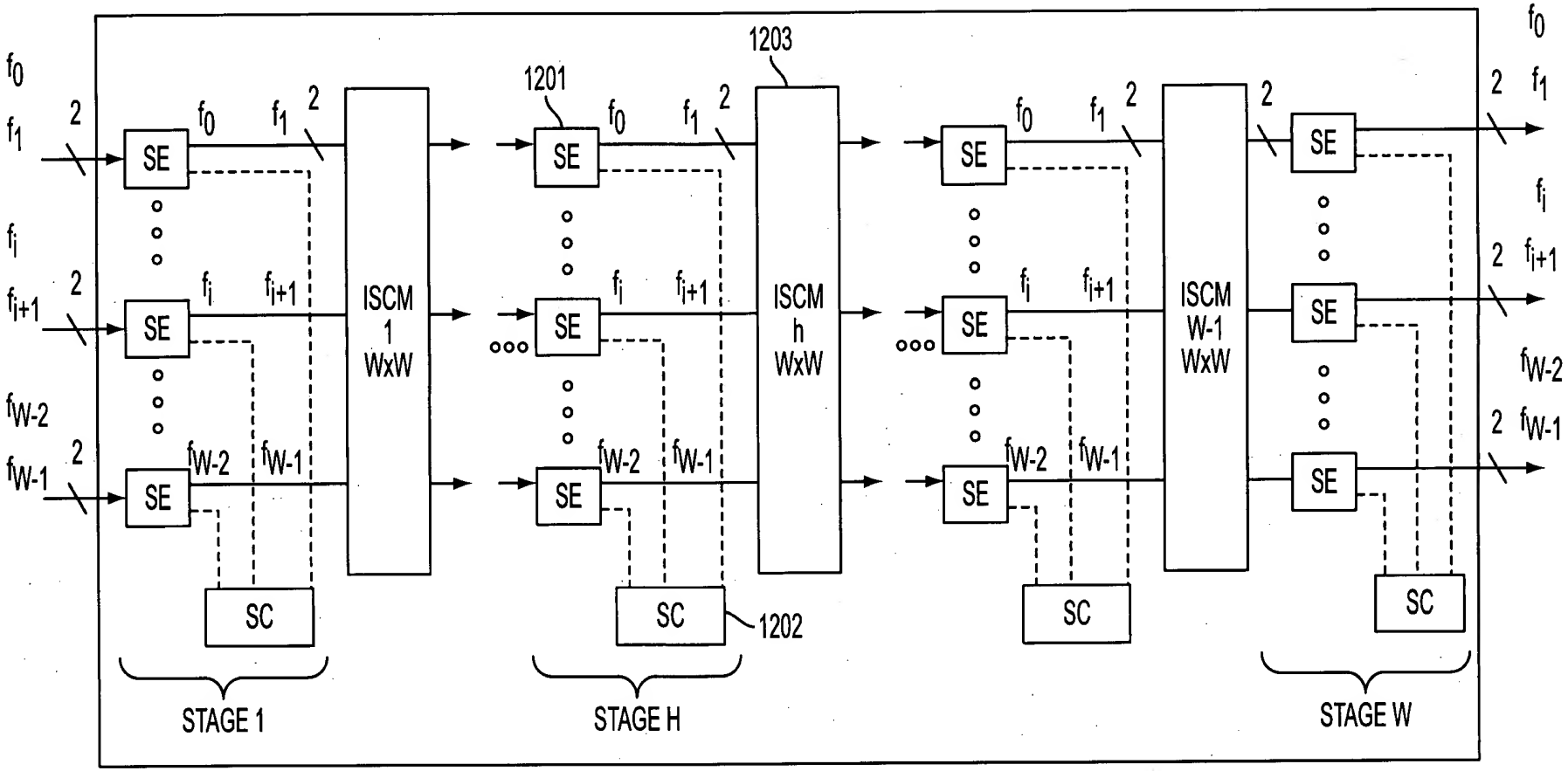


FIG. 12

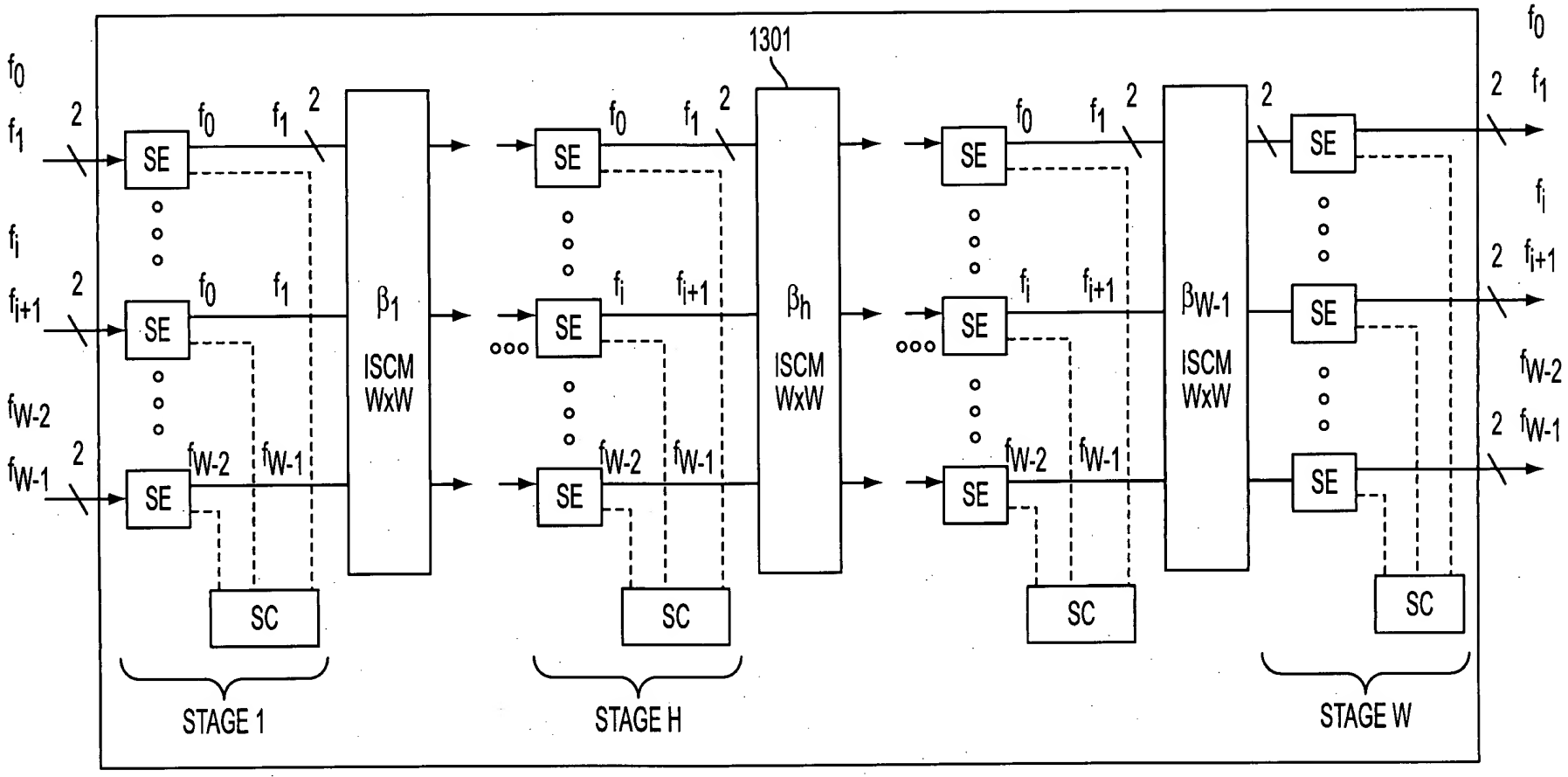


FIG. 13

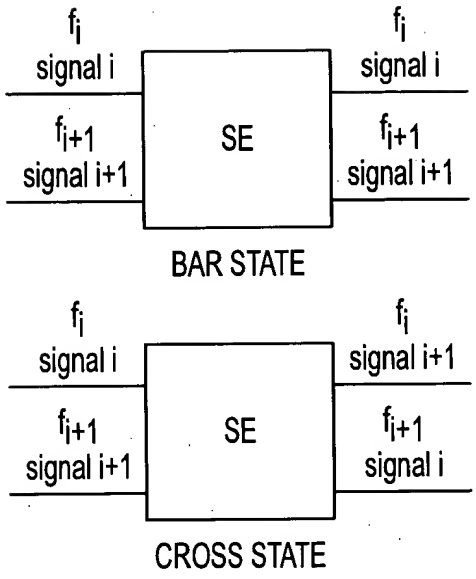

f_i
signal i
f_{i+1}
signal i+1
SE
f_i
signal i
f_{i+1}
signal i+1
BAR STATE
f_i
signal i
f_{i+1}
signal i+1
SE
f_i
signal i+1
f_{i+1}
signal i
CROSS STATE

FIG. 14

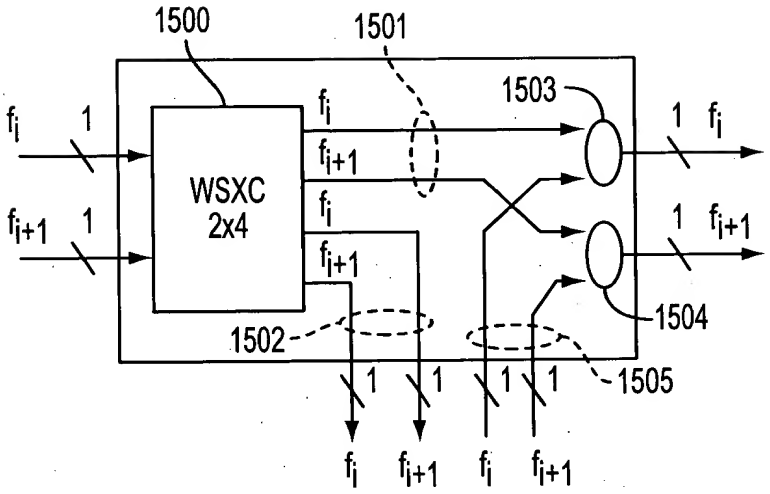


FIG. 15

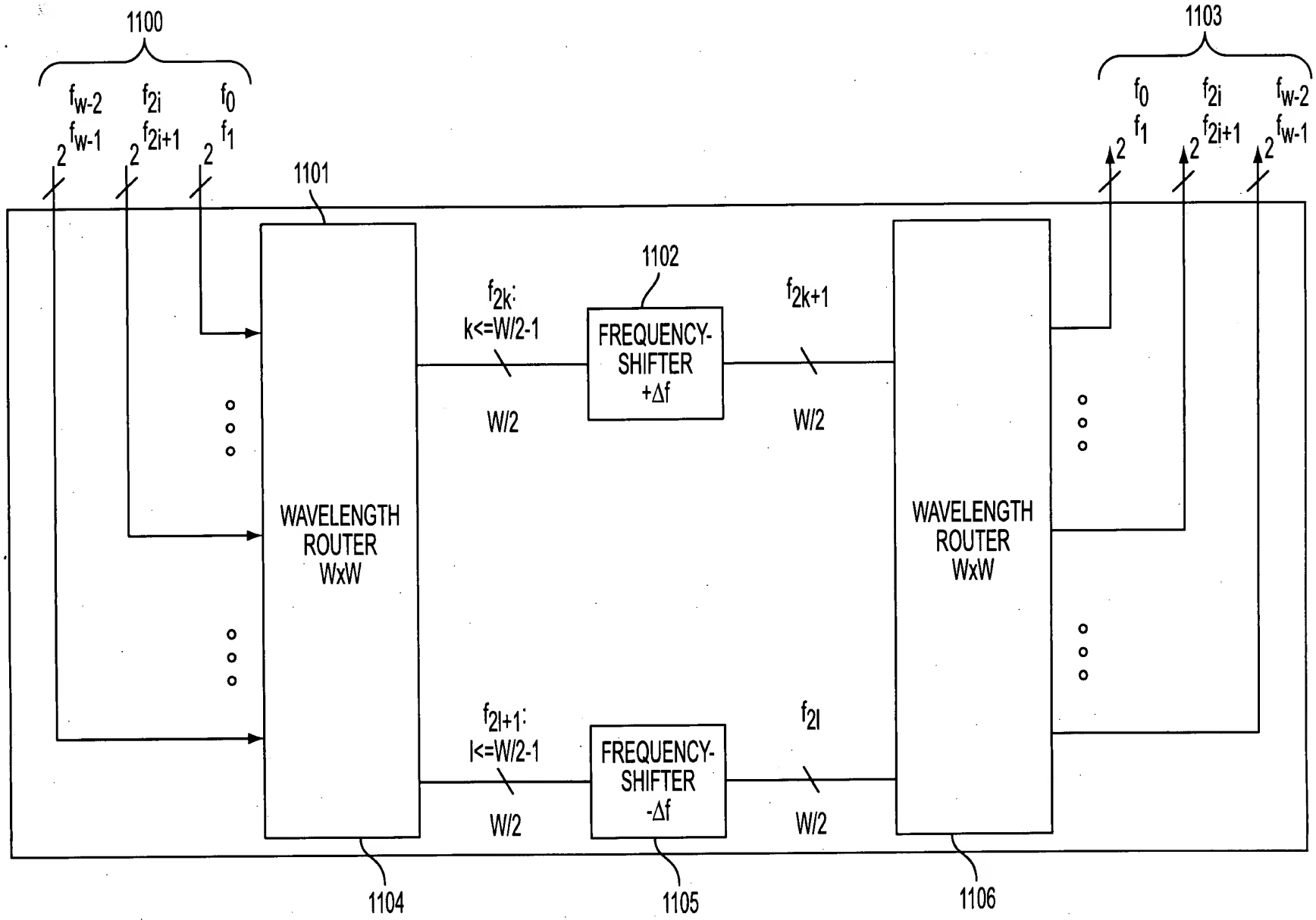

1100
f_{w-2} f_{w-1}
f_{2i} f_{2i+1}
f_0 f_1
2
1101
WAVELENGTH ROUTER WxW
f_{2k}: k<=W/2-1
W/2
1102
FREQUENCY-SHIFTER +Δf
f_{2k+1}
W/2
1103
f_0 f_1
f_{2i} f_{2i+1}
f_{w-2} f_{w-1}
WAVELENGTH ROUTER WxW
f_{2l+1}: l<=W/2-1
W/2
FREQUENCY-SHIFTER -Δf
f_{2l}
W/2
1104
1105
1106

FIG. 16

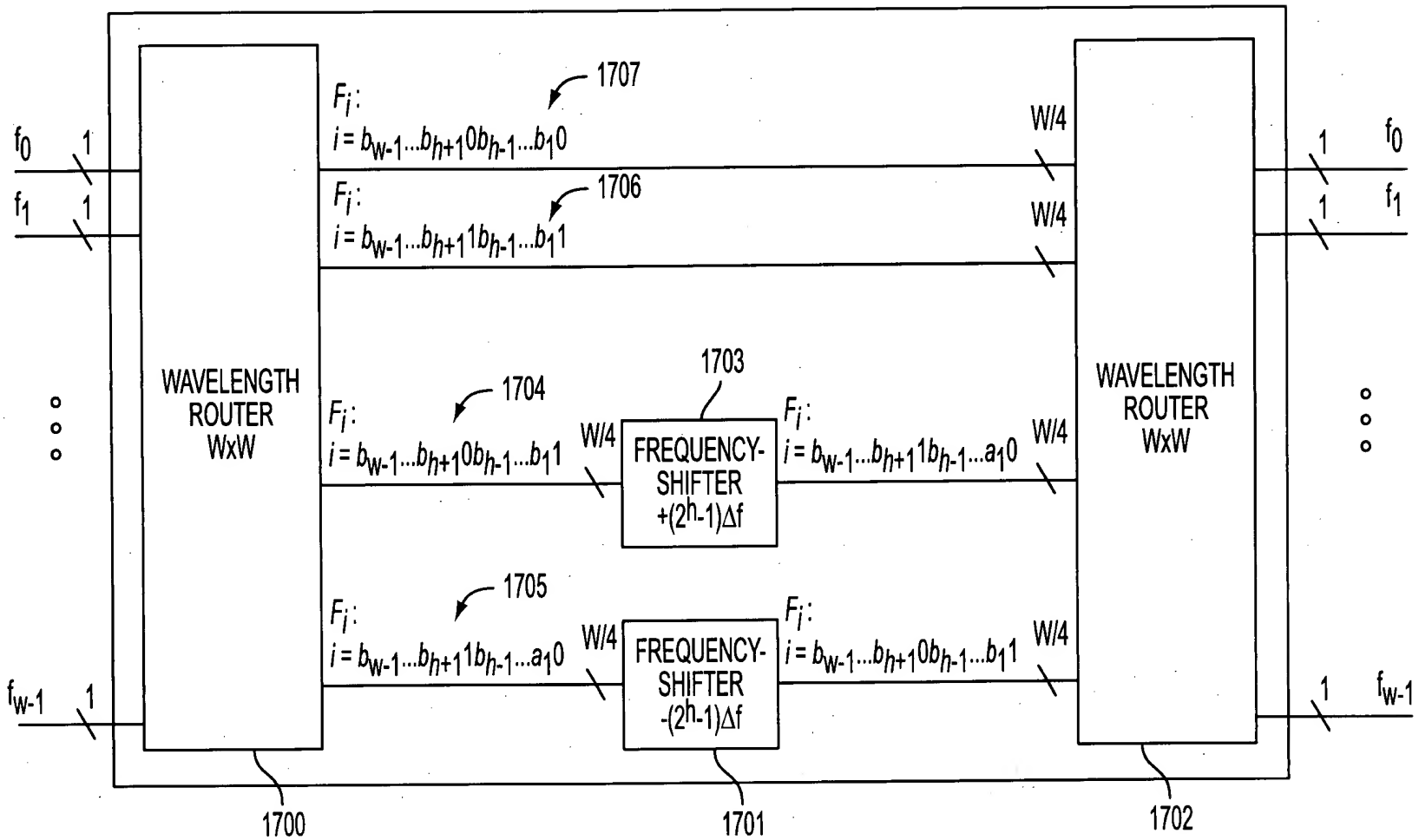

f_0
f_1
f_{W-1}
1
WAVELENGTH ROUTER WxW
1700
F_i:
$i = b_{W-1}...b_{h+1}0b_{h-1}...b_10$
1707
F_i:
$i = b_{W-1}...b_{h+1}1b_{h-1}...b_11$
1706
F_i:
$i = b_{W-1}...b_{h+1}0b_{h-1}...b_11$
1704
F_i:
$i = b_{W-1}...b_{h+1}1b_{h-1}...a_10$
1705
W/4
1703
FREQUENCY-SHIFTER
$+(2^h-1)\Delta f$
FREQUENCY-SHIFTER
$-(2^h-1)\Delta f$
1701
F_i:
$i = b_{W-1}...b_{h+1}1b_{h-1}...a_10$
F_i:
$i = b_{W-1}...b_{h+1}0b_{h-1}...b_11$
WAVELENGTH ROUTER WxW
1702

FIG. 17

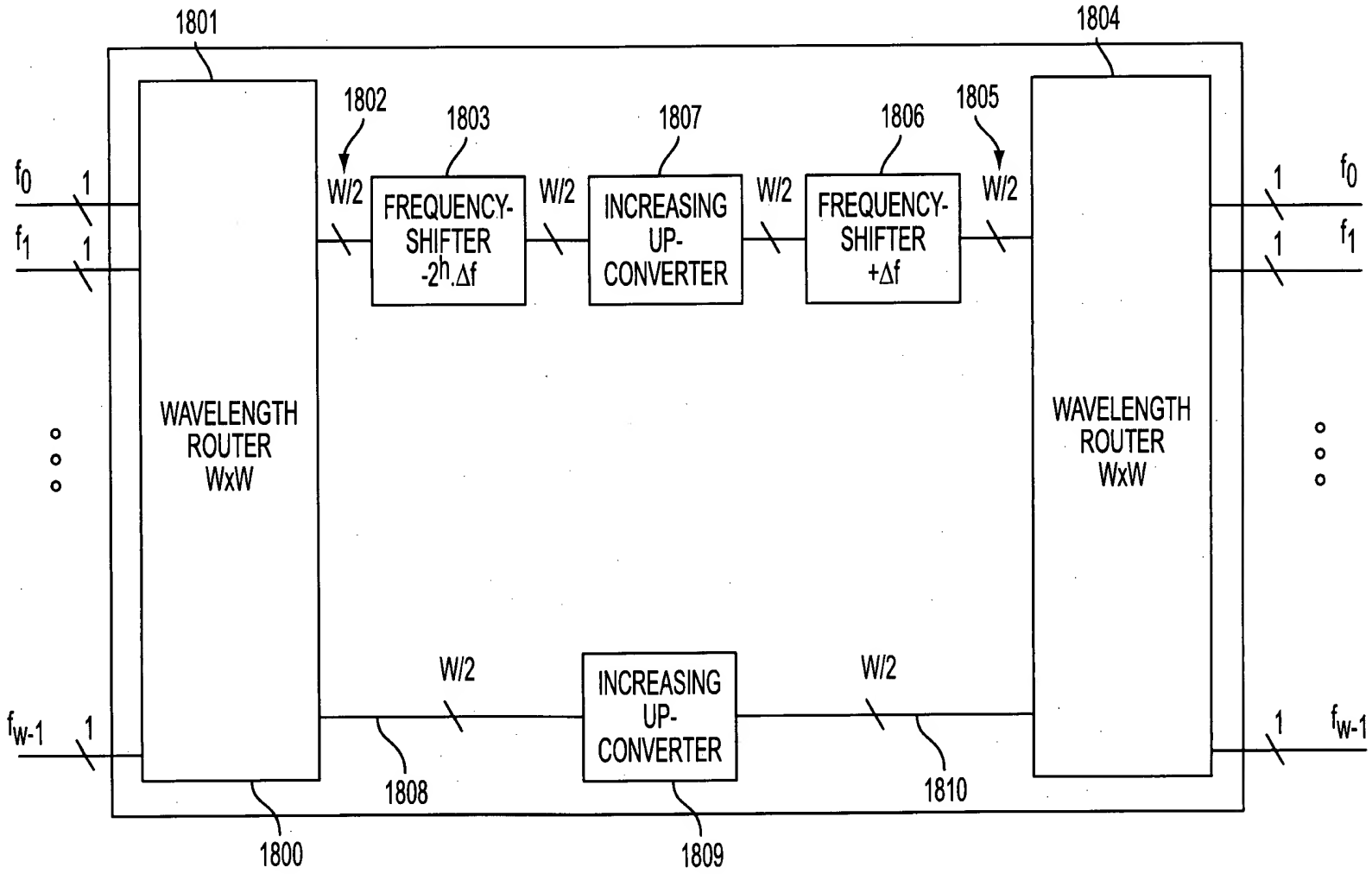


FIG. 18

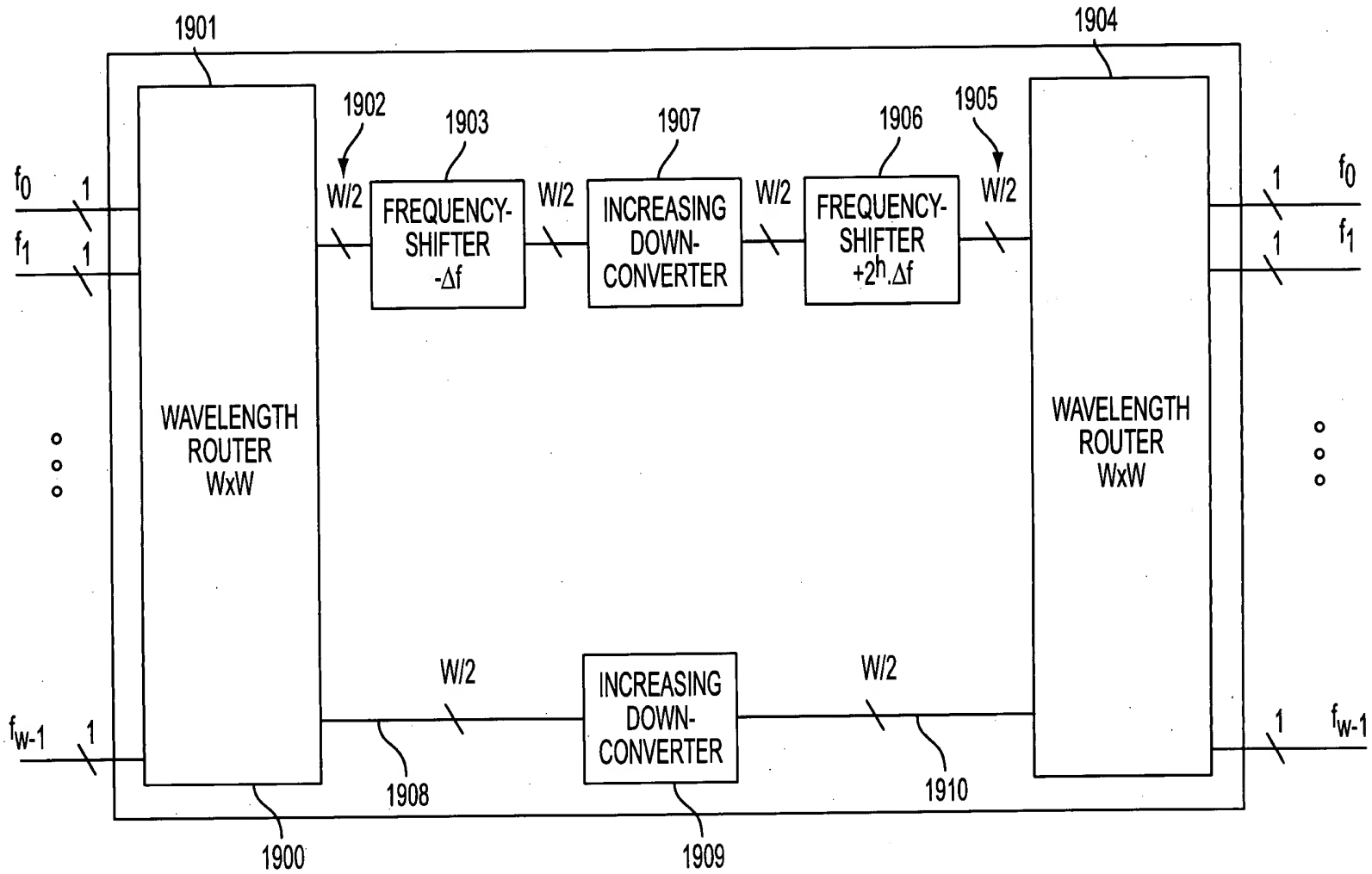

1901
1904
1902
1903
1907
1906
1905
f_0
1
f_1
1
W/2
FREQUENCY-SHIFTER -Δf
W/2
INCREASING DOWN-CONVERTER
W/2
FREQUENCY-SHIFTER $+2^h.\Delta f$
W/2
1
f_0
1
f_1
WAVELENGTH ROUTER WxW
WAVELENGTH ROUTER WxW
W/2
INCREASING DOWN-CONVERTER
W/2
f_{W-1}
1
1
f_{W-1}
1908
1910
1900
1909

FIG. 19

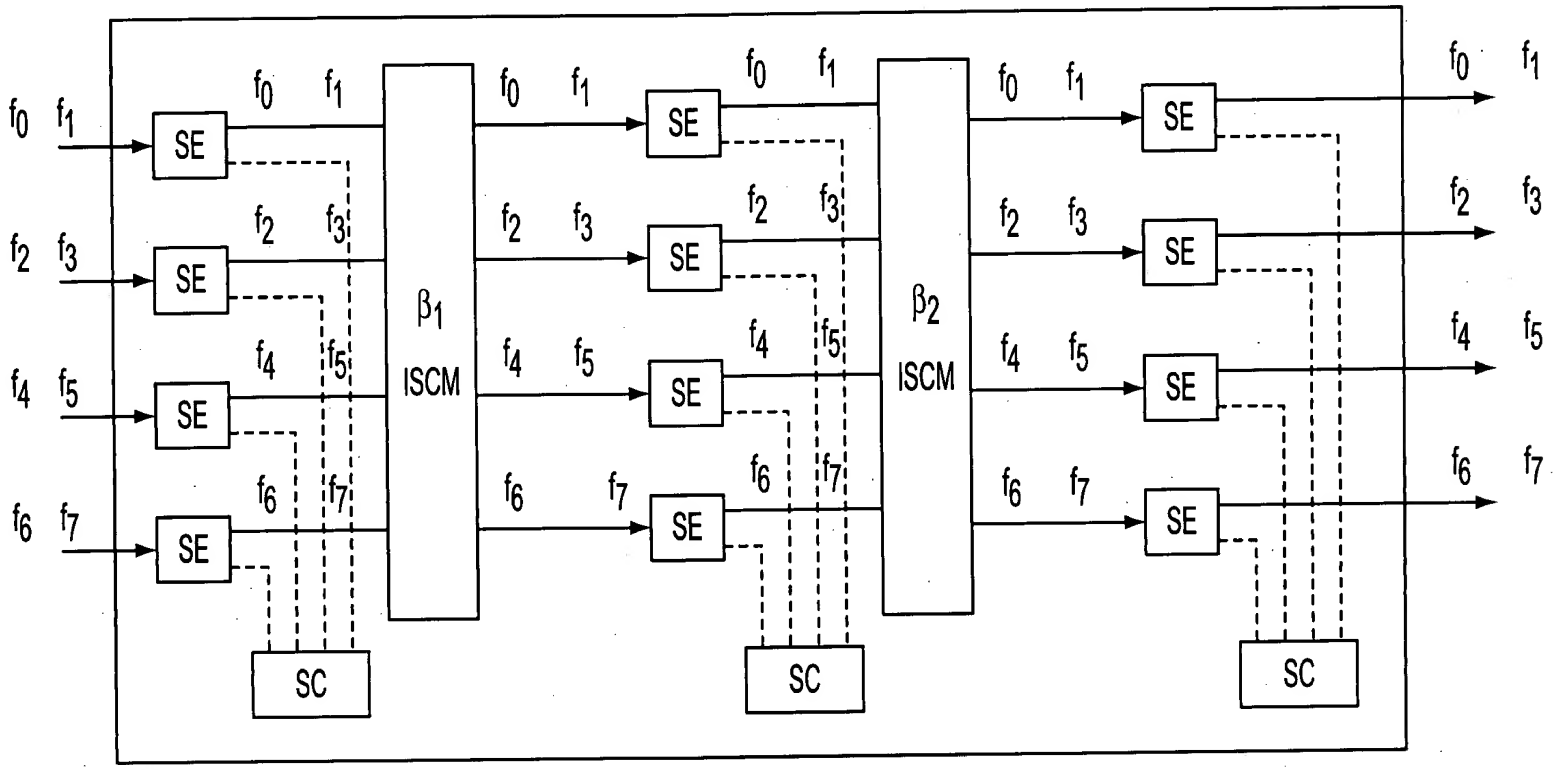


FIG. 20

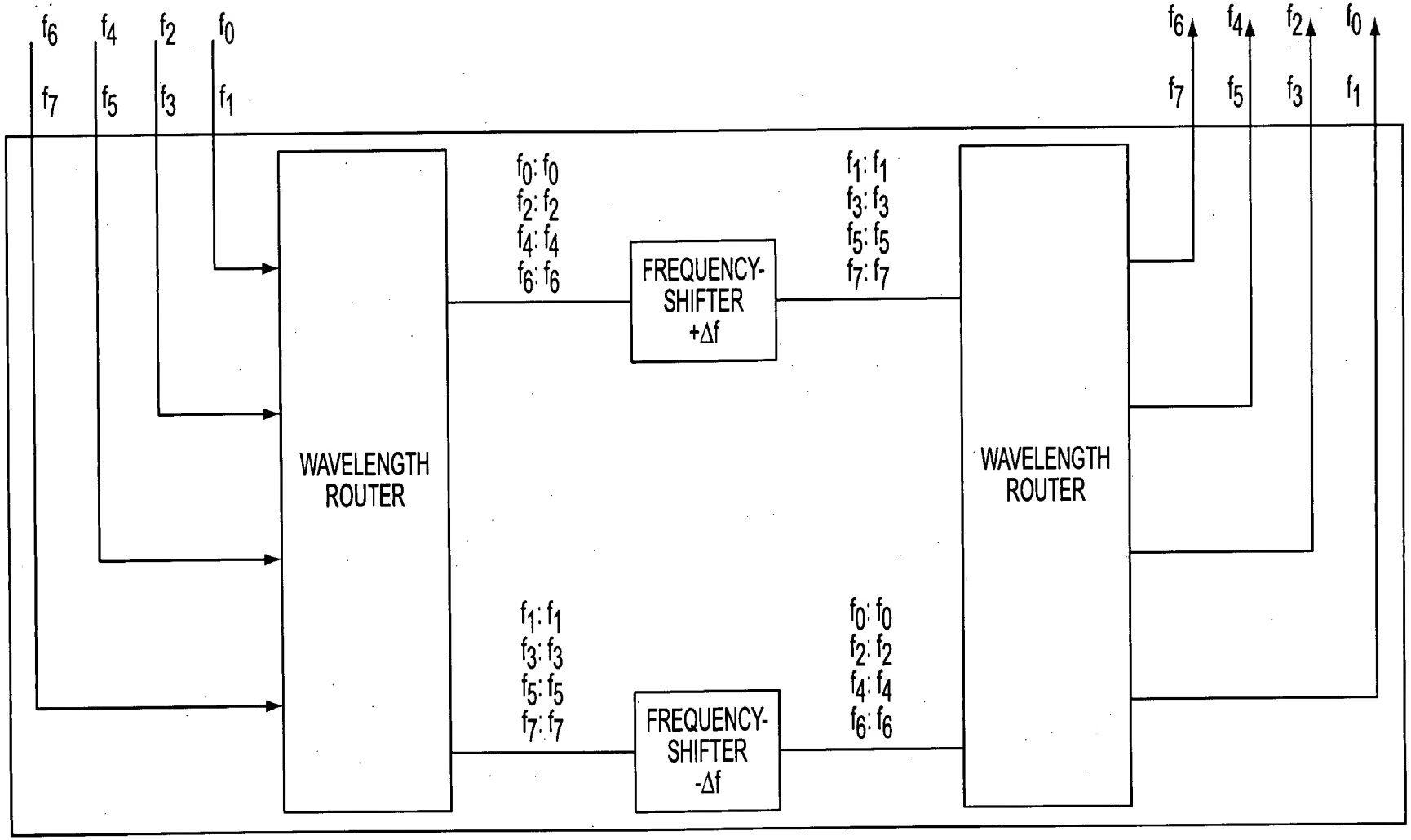

f6 f4 f2 f0
f7 f5 f3 f1
WAVELENGTH ROUTER
f0: f0
f2: f2
f4: f4
f6: f6
FREQUENCY-SHIFTER +Δf
f1: f1
f3: f3
f5: f5
f7: f7
WAVELENGTH ROUTER
f6 f4 f2 f0
f7 f5 f3 f1
f1: f1
f3: f3
f5: f5
f7: f7
FREQUENCY-SHIFTER -Δf
f0: f0
f2: f2
f4: f4
f6: f6

FIG. 21

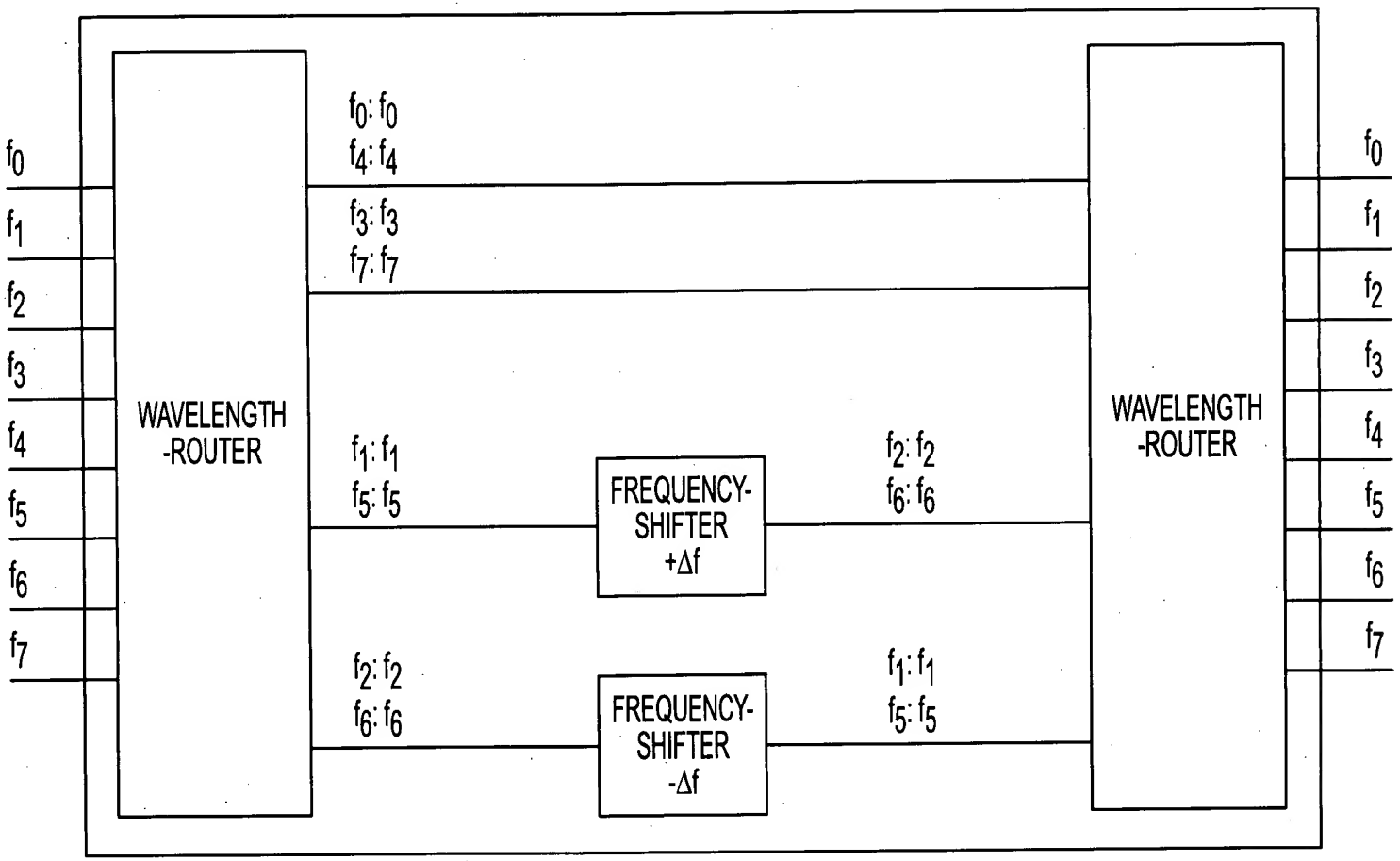


FIG. 22

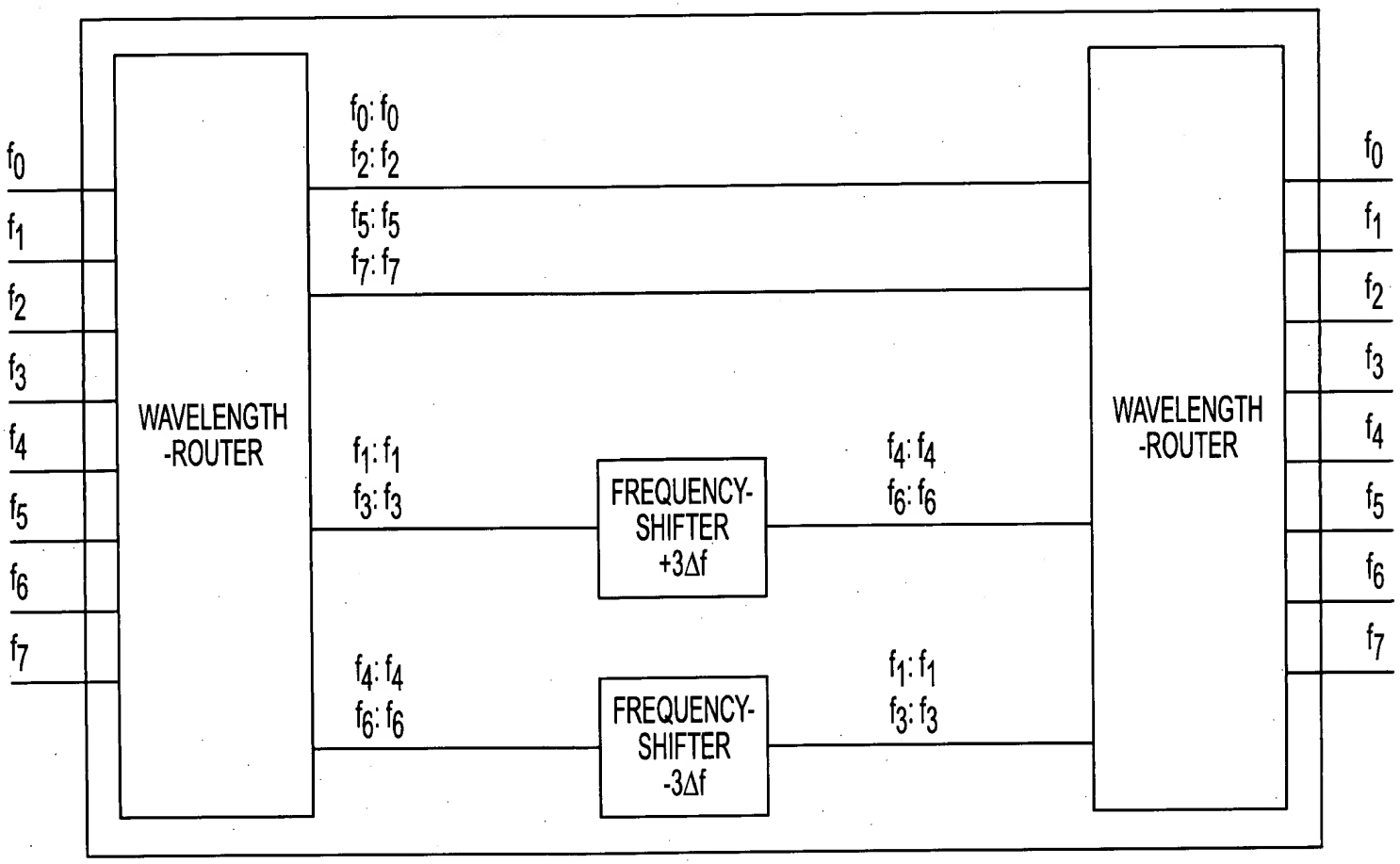


FIG. 23

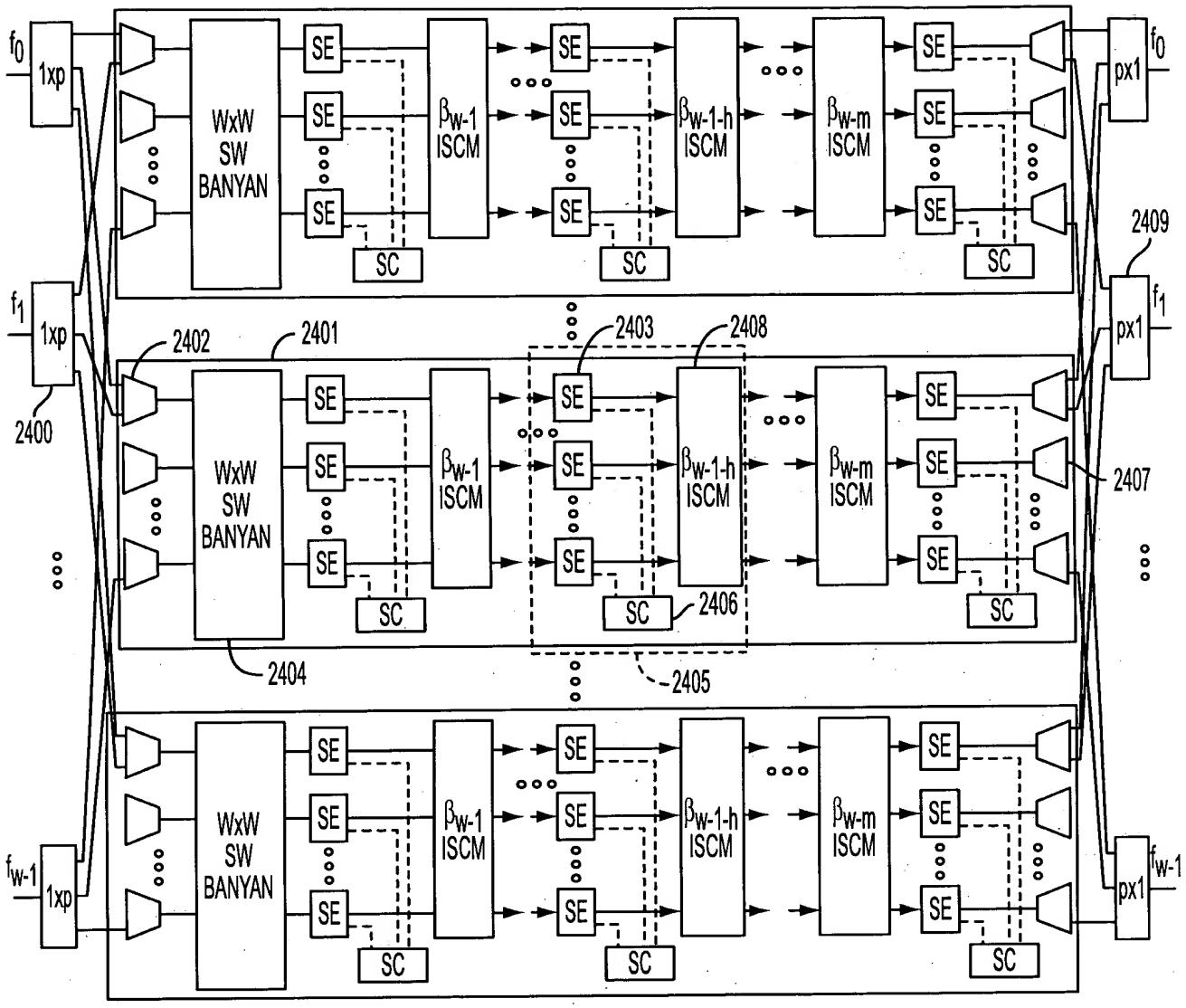

f_0
1xp
f_1
1xp
f_{w-1}
1xp
2400
2402
2401
2403
2408
2404
2405
2406
2407
2409
WxW SW BANYAN
SE
SC
β_{w-1} ISCM
β_{w-1-h} ISCM
β_{w-m} ISCM
px1
f_0
f_1
f_{w-1}

FIG. 24

	P(0)	P(h) 0<h<n	P(n)
OMEGA	σ_{n-1}	σ_{n-1}	J
OMEGA^{-1}	J	σ_{n-1}^{-1}	σ_{n-1}^{-1}
SW-BANYAN	J	β_h	J
SW-BANYAN^{-1}	J	β_{n-h}	J
N-CUBE	σ_{n-1}	β_{n-h}	J
N-CUBE^{-1}	J	β_h	σ_{n-1}^{-1}
BASELINE	J	σ_{n-h}^{-1}	J
BASELINE^{-1}	J	σ_h	J

FIG. 25

COMPONENT	NUMBER	FREQUENCY-SHIFTERS
STATE CHANGER	$\log_2(W)$	2
BUTTERFLY ISCM	$\log_2(W)$ -1	2

FIG. 26

SELF-ROUTING NETWORK	NUMBER OF FREQUENCY-SHIFTERS
SW-BANYAN	$O(\log_2 W)$
BASELINE	$O((\log_2 W)^2)$
N-CUBE	$O(\log_2 W)$
OMEGA	$O((\log_2 W)^2)$

FIG. 27

NETWORKS	NEAR-OPTIMAL PARAMETER CHOICE	WAVELENGTH-INTERCHANGER FREQUENCY-SHIFTER COMPLEXITY	OVERALL SEPARABLE CROSS-CONNECT FREQUENCY-SHIFTER COMPLEXITY
NEAR-OPTIMAL REARRANGEABLY NONBLOCKING	$m = w\text{-}1$ $p = 1$	$4w\text{-}4$	$4.F.(w\text{-}1)$
NEAR-OPTIMAL STRICTLY-NONBLOCKING	$m = w\text{-}1$ $p = w$	$4.w^2\text{-}4.w$	$4.F.w.(w\text{-}1)$

FIG. 28